UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
WASHINGTON, D. C.
H. H. BENNETT, CHIEF

ADVANCE REPORT

on the

SEDIMENTATION SURVEYS OF LAKES CROOK AND GIBBONS PARIS, TEXAS

February 27 - March 27 and March 25 - 31, 1936

by

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Sedimentation Studies
Division of Research
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ADVANCE REPORT ON THE

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PARIS, TEXAS

GENERAL INFORMATION

Location (fig.1):

State: Texas.

County: Lamar.

Distance and direction from nearest city: Lakes Crook and Gibbons are 4½ miles north and 6 miles northwest, respectively, of Paris.

Drainage and backwater: Lake Crook dam is on Pine Creek, a tributary of the Red River, and impounds water on both the north and south branches. Lake Gibbons dam is on a small tributary of the north branch of Pine Creek, about 2 miles above Lake Crook.

Ownership: City of Paris.

Purpose served: Lake Crook is the present source and Lake Gibbons is the former source of municipal water supply.

Description of Lake Crook dam and reservoir: The dam is an earth-fill structure, 3,100 feet long and 38 feet in maximum height above the original valley bottom. The top of the dam is 487.6 feet above mean sea level and is 20 feet wide. The slope of the upstream face is 1½:1 above the spillway crest level and 3:1 below. A concrete facing 1 foot thick covers the upstream slope to a height of 6 feet above crest level.

A concrete overflow spillway 300 feet long is situated approximately at the middle of the dam. The spillway crest, which determines the shore line used in this survey, is 476 feet above mean sea level, or 11.6 feet below the top of the dam.

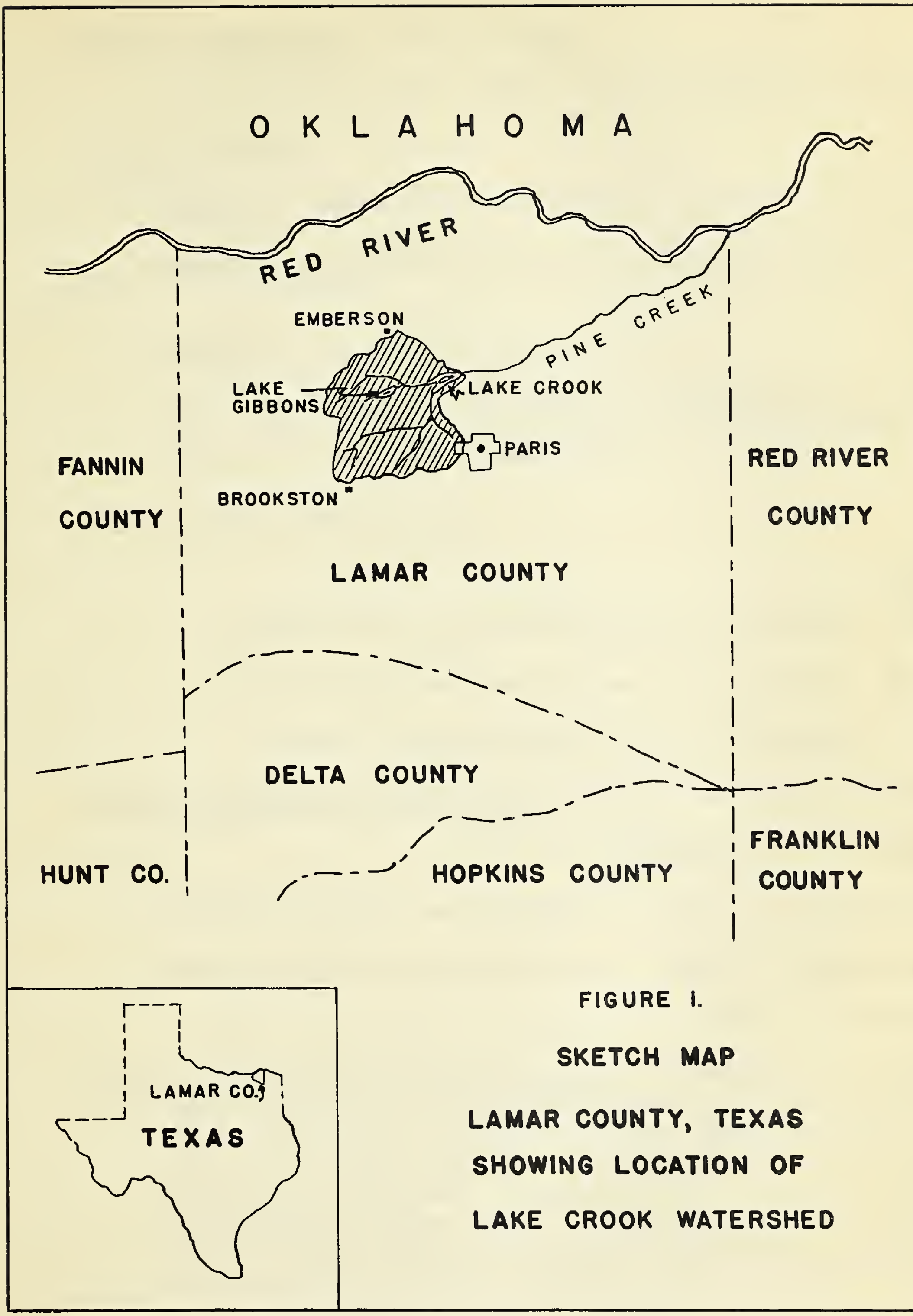

FIGURE 1.

SKETCH MAP

LAMAR COUNTY, TEXAS SHOWING LOCATION OF LAKE CROOK WATERSHED

Date of completion: February 1923.

Date of survey: March 1936. Age of reservoir: 13.1 years.

Length of lake:

Original: 2.9 miles from the dam to the heads of both arms.

Present: 2.7 miles on the south arm and 2.9 miles on the north arm.

Decrease: 0.2 mile on the north arm.

The above lengths do not include narrow ponded channels which extend 3,300 and 4,000 feet, respectively, above the heads of the south and north arms.

Area of lake at crest stage:

	Acres
Original area	1,291
Present area	1,227
Decrease	64

Storage capacity at crest stage (determined by this survey):

	Acre-feet	Gallons
Original capacity	11,487	3,743,038,950
Present capacity	10,755	3,504,516,750
Loss due to silting	732	238,522,200

General character of reservoir basin. The length of the main basin, exclusive of the narrow ponded channels at the heads of the two arms, is roughly 3 miles. About 1.7 miles above the dam a low spur divides the lake into two arms of nearly equal size, which average approximately 1 mile in length and 2,000 feet in width. Below the junction of the two arms the average width of the main lake is about 3,000 feet. The shore line is moderately sinuous, and the submerged slopes

are gentle, except in a few places where the old channel, by lateral cutting, had encroached upon the valley side. The lake had a maximum original depth of 24 feet in the submerged channel near the dam and diminished gradually and uniformly in depth to the heads of the two arms.

Description of Lake Gibbons dam and reservoir. The dam is of earth-fill construction and has a maximum height of 46 feet above the original valley bottom and an over-all length, including the spillway, of 2,560 feet. It is V-shaped in plan, its center being about 500 feet downstream from the ends. The crest of the dam is 610 feet above mean sea level and is 15 feet wide. The slope of the upstream face is 2:1, and of the downstream face, $1\frac{1}{3}$:1. A riprap of concrete blocks covers the upstream face to a height of 4 feet above crest level, and a thick growth of grass and trees effectively checks erosion by rainwash on the crown and upper slopes.

A concrete spillway, with a crest length of 20 feet, connects the earth fill with the west valley wall. The spillway crest was originally 602 feet above sea level and 38 feet above the original channel, but was lowered 3 feet in 1932 to an elevation of 599 feet. Discharge from the lake reaches the spillway by way of a canal about 20 feet wide and 400 feet long. Under varying conditions of high and low water the canal is subject alternately to erosion and deposition, and at the time of survey its floor was 0.75 foot above the crest of the spillway. The spillway, therefore, does not determine the exact level of the lake at all times. Contour 599, however, was used in the computations included in this report.

Date of completion: 1900 (month undetermined).

Date of survey: March 1936. Age of reservoir: 36 years.

Length of lake (original and present): 1 mile, not including 1,100 feet of ponded channel at the upper end.

Area of lake at crest stage:

	Acres
Original area	131.3
Present area	130.5
Decrease	0.8

Storage capacity at crest stage (determined by this survey):

	Acre-feet	Gallons
Original capacity	1,414	460,751,900
Present capacity	1,336	435,335,600
Loss due to silting	78	25,416,300

Areas of watersheds (as mapped by Section of Conservation Surveys, Soil Conservation Service):

Lake Creek (exclusive of Lake Gibbons drainage area): 51.6 square miles.

Lake Gibbons: 1.26 square miles.

General character of the combined watersheds.[1]

Geology. The watershed above the two dams lies entirely within the West Gulf section of the Coastal Plain province. It is underlain by three formations of Upper Cretaceous age, the Bonham clay, the Blossom sand, and the Brownstown marl, which, in the current usage of the U. S. Geological Survey, are grouped under the name of Austin chalk. The Bonham clay underlies the northern two-thirds of the area, and the remaining third is about equally divided between the Blossom sand, which forms a mile-wide belt extending westward from Paris, and the Brownstown marl in the extreme southern end of the watershed.

Drainage and topography. Drainage lines of the region follow a gentle slope northeastward to the Red River. The principal streams of the area are the north and south branches of Pine Creek, which unite $1\frac{1}{4}$ miles above Lake Creek dam. A small tributary of North Pine Creek is the main feeder stream of Lake Gibbons. Overflow from Lake Gibbons follows an eastward course

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[1] Much of the following information, particularly on erosion, slopes, soils, and land use, was obtained from an unpublished report by Harvey Oakes, entitled "Soil Conservation Survey of Lake Creek Watershed, Paris, Texas", based on field work completed in February 1937 by the Section of Conservation Surveys, Division of Operations, Soil Conservation Service.

for about 2 miles and enters the north arm of Lake Creek by way of North Pine Creek.

The area as a whole is characterized by undulating to gently rolling topography and a well-developed dendritic drainage system. Near the heads of small streams there are some relatively flat areas as much as a mile in width. Separating upland flats and valley bottoms are slopes as high as 10 or 15 percent which, however, represent only a very small part of the total area. The bottomlands along Pine Creek and its larger tributaries are level to gently rolling. No noticeable terraces have been developed.

Elevations range from 488 feet at the shore of Lake Creek to about 650 feet at the upper end of the watershed, but the valley bottoms are rarely more than 80 feet below the level of the adjacent uplands.

Soils. The watershed lies in the transitional zone between the two soil regions known as the East Texas Timber country and the Blackland Prairie region of Texas. The principal soils have been developed from the soft shales known as the Bonham clay and, to some extent, from the calcareous clays known as the Brownstown marl. The principal soil groups and their proportionate areas in the watershed are listed in table 1.

The four groups include 13 distinct soil types, of which 9 are residual soils of the Wilson, Crockett, and Houston series, and 4 are alluvial soils of the Ochlockonee series. In general, all the soils have loose and friable topsoils and heavy, slowly permeable subsoils, conditions highly favorable for rapid run-off and serious soil losses.

Table 1.--Description and area of principal soil groups in the Lake Creek and Lake Gibbons watersheds

Group	Description	Area
		Percent
1....	Heavy clay and clay loams. Relatively deep with heavy, slowly permeable clay subsoil.......	17.3
2....	Friable but rather heavy fine and very fine sandy loams. Shallow with heavy, slowly permeable clay subsoil.........................	60.6
3....	Heavy, very fine sandy loams. Shallow to moderately deep with heavy impermeable clay subsoil..	11.5
4....	Alluvial and colluvial soils of variable texture, chiefly silty clay loam and fine sandy loam with granular, moderately permeable subsoil..........	10.6
Total	....	100.0

Erosion conditions. The relative extent of different degrees of erosion in the combined watersheds is given in the following tabulation:

Degree of erosion:	Percent
No apparent erosion, including areas of recent alluvial and colluvial deposits.......	25.5
Slight erosion	43.1
Moderate erosion	25.8
Severe erosion	4.1
Very severe erosion	1.5

Erosion of the moderate and more severe types is confined almost entirely to lands that are in cultivation or have been cultivated in the past. Woodlands and permanent meadows are the least affected by accelerated erosion. On the cultivated lands, in almost every case, the most severely eroded areas occur on the steeper slopes. The steepest slopes of the watershed, however,

are not seriously eroded, because, being too steep to cultivate, they have been allowed to retain their original protective cover of native vegetation. The most severe erosion has occurred on cultivated slopes of 2 to 6 percent.

Land Use. The proportionate areas devoted to different types of land use in 1937 are as follows:

Type of land use:	Percent
Crop land	33.5
Pasture	25.2
Permanent meadow	14.7
Woodland	13.3
Idle land	10.7
Farmsteads and urban areas	2.6

The principal crops are cotton, corn, oats, and hay. Some livestock is raised on almost every farm. A considerable amount of hay is produced from the native meadows.

Mean annual rainfall. 38.94 inches, according to a 39-year record of the U. S. Weather Bureau at Paris, Texas.

Draft on reservoirs.

Lake Crook:	Gallons per day
Summer maximum	1,800,000
Minimum	700,000
Average	1,000,000

The average daily per capita consumption is 64 gallons. The water of Lake Crook has a high degree of purity, having accumulated in a watershed underlain by essentially non-calcareous, slightly sandy shale. The following analysis of raw water from Lake Crook was made by J. B. Hawley Company, Engineers, Fort Worth, Texas, from a sample taken November 4, 1934:

Suspended matter:	Parts per million
Fixed	34.5
Volatile	11.5
Total dissolved solids on evaporation at 18°C.	152.0
Silica	15.4
Alumina	1.6
Iron	0.14
Magnesium	3.8
Sodium	7.9
Sulfate	19.1
Chlorine	5.0
Bicarbonate	98.8
Total calcium carbonate	81.0

Lake Gibbons. No water has been drawn from Lake Gibbons since Lake Crook was put in use in 1923.

HISTORY OF SURVEYS

The sedimentation surveys of Lakes Crook and Gibbons were made during the periods February 27 to March 27, and March 25 to 31, 1936, respectively, by the central reservoir party, Section of Sedimentation Studies, Division of Research. The party consisted of L. M. Glymph, Jr., chief, V. H. Jones, assistant chief, E. M. Flaxman,[2] W. G. Shannon, H. L. Fischer, and O. D. Price.

Original and present (March 1936) capacities and silt volumes were determined for each reservoir by the range method of survey.[3] This involved the measurement of water and silt depths on 18 ranges in Lake Crook and 8 ranges in Lake Gibbons. All mapping was done with plane table and telescopic alidade, on a scale of 500 feet to the inch on Lake Crook and 300 feet to the inch on Lake Gibbons, corresponding to the scales of the original shore-line maps.

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[2] Mr. Flaxman was transferred to the western reservoir party as party chief on March 4, 1936.

[3] Eakin, H. M. Silting of Reservoirs. U. S. Dept. Agr. Tech. Bull. 524: 128-137, 1936.

On Lake Crook a primary control system of 20 triangulation stations was expanded from a 3,075-foot base line chained along the center line of the dam. Several of these stations were also used as range ends. Additional range ends, and the plane-table stations used in mapping shore line and in intersecting ranges, were established by stadia. The shore line was taken in large part from an original map furnished by the city engineer, but it was necessary to remap several miles at the head of each arm to show greater detail and to show the present shore line where it had been shifted by sedimentation.

A map of Lake Gibbons made in 1935 was used as a base for the 1936 survey. This map, which had been made by the transit-stadia method, was checked by triangulation and corrected in places by relocating certain control points and remapping sections of shore line to agree with the adjustments. The shore line at the upper end of the lake was also remapped to show greater detail of the ponded channel and to show the present shore line where it had been shifted by accumulation of sediment above crest level.

To facilitate resurveys, all range ends and cut-in stations on both lakes, the ends of the base line across the dam on Lake Crook, and the original control points on Lake Gibbons were marked with iron pipe stamped with the station numbers and set in concrete.

ACKNOWLEDGMENTS

The Soil Conservation Service acknowledges the helpful cooperation of the City of Paris during the course of the surveys. W. F. Hicks, city engineer, furnished maps and information, and made arrangements for securing materials for the survey monuments. Thanks are due to Pete Moss, chief of the Paris Fire Department, and to Hook Boyd for the use of boats during both surveys.

SEDIMENT DEPOSITS IN LAKES CROOK AND GIBBONS

Character of Sediment

The sediment in both reservoirs consists almost entirely of silt and clay but includes some very fine sand. The bottoms of both lakes are covered with a thin blanket of soft, relatively uncompacted blue-gray silt, which is remarkably uniform in composition and comparatively free of carbonaceous material or vegetal debris. All the silt samples from marginal areas of the lakes were sandy and showed evidence of sorting by wave and current action along the shores. The delta de-

posits at the heads of Lake Gibbons and the north arm of Lake Crook consist of irregularly stratified very fine sand, silt, and clay.

Distinctions between lake sediments and the underlying materials were made on the basis of several conspicuous differences in character. On nearly all submerged flat areas the spud entered a black sticky soil beneath the silt. The soil adhered to the spud tenaciously while the silt was readily washed off. Beneath the silt in the submerged channel a more or less oxidized fine sand was almost invariably penetrated. In the delta areas of both reservoirs, borings through the sandy lake deposits revealed a much more compact valley soil beneath. In some places near the original channel of each lake the spud passed through the silt into relatively fresh shale, showing an absence of true soil.

Distribution of Sediment

Lake Crook. (Fig. 3 following p.15)

The distribution of the sediment, like its character, is strikingly uniform; on nearly all ranges the average thickness falls between 0.5 and 1 foot. Some measurements made in the old channel exceed 2 feet. In only two parts of the lake has sediment been concentrated; namely, the submerged creek channel, and the delta at the head of the north arm (figs. 2 and 3).

The delta has been formed by the accumulation of sand and silt above a road fill which extends directly across the arm. Inflowing water from the tributaries entering this arm must reach the main lake through two small channels, one near each end of the fill. In this artificial settling basin a delta of sand and silt averaging nearly 2.5 feet thick has accumulated. The deposit diminishes in thickness upstream and finally thins out at an average distance of 1,100 feet above the road fill. It is now traversed by many irregular channels and small bayous, and supports a dense growth of willows, grass, and cockleburs.

The south arm, having no obstruction across it, lacks a delta; in fact, on this arm very little sediment of any kind occurs, even in the numerous re-entrants of the irregular shore line at the upper end.

Lake Gibbons (Fig. 4 following p. 15)

The sediment in Lake Gibbons is fairly uniformly distributed over the reservoir bottom. On ranges RI-R2 and R3-R4, near the dam, thickness measurements on the submerged flat areas commonly range from

0.5 to 1 foot, and the maximum thickness is slightly over 2 feet in the old channel. Similar relative silt depths were found on ranges farther up the lake. On range R9-R10, where the old channel had encroached upon the west valley side, a silt thickness of 5.4 feet was measured. This is the maximum thickness for the lake, but represents only a very small area of channel fill.

A small delta in the narrow ponded channel at the head of the lake has formed two sinuous bars, one along each shore, as well as a small island near midchannel (fig. 3). This deposit has a total length of 450 feet, an average width of about 100 feet, and a maximum thickness of 3.6 feet near its lower end.

The high turbidity of the overflow, observed at both Lake Crook and Lake Gibbons dams during seasons of greatest run-off, indicates that a considerable fraction of the incoming silt load is carried in suspension entirely through each reservoir before having a chance to settle; the volume of silt in the two basins, therefore, does not represent the entire erosional output of the watershed.

Origin of Sediment

Sheet erosion from cultivated areas with gentle slopes, devoted largely to clean-tilled row crops, is the principal source of sediment in the reservoir. Gully erosion, although more noticeable, is much less extensive and hence less important as a source of sediment. Although the soils of the watershed as a whole are potentially highly erodible, serious soil washing has occurred only where the native grass and forest cover has been supplanted by cultivated crops.

A study of the available information on the source of reservoir sediment brings to light several important facts. The more significant data are summarized in table 2.

Figure 2.--Willows growing in west end of Lake Crook on deposits of soil material washed from surrounding farm lands.

Table 2.--Comparison of data on the Lake Creek and Lake Gibbons watersheds and reservoirs

Unit	Lake Creek	Lake Gibbons
Watershed:		
Total area....................square miles...	51.6	1.26
Cultivated........................percent...	33.9	17.3
Idle.....................................do.....	10.9	2.4
Pasture and woodland.................do.....	39.1	14.9
Permanent meadow......................do.....	13.4	65.4
Farmsteads and urban areas............do.....	2.7	0
Area on B slopes[1]......................do.....	53.6	71.5
Area with moderate to severe erosion...do.....	31.8	17.7
Reservoir:		
Original storage per square mile of drainage area...................acre-foot	223	1,122
Annual sediment accumulation per square mile of drainage area..........do.....	1.08	1.72

[1]On this survey, B slopes are 1 to 6 percent. Only 3.5 percent of the combined area of the two watersheds is on slopes above the B group.

These data show that the Lake Creek watershed, with more than twice as much of its area in cultivated and idle land, has a correspondingly larger part of its area suffering moderate to severe erosion, and thus might be expected to have a greater silt output per unit of drainage area. Table 2 shows, however, that the annual rate of accumulation in Lake Creek per square mile of drainage area is considerably less, instead of greater, than the rate of Lake Gibbons.

There can be little doubt, in view of the more serious erosion conditions, that the average loss of topsoil per unit of area has been greater in the Lake Creek watershed. Why, then , is this greater soil loss not reflected by a correspondingly greater silt accumulation in the receiving reservoir? A study of the available information reveals two facts which probably account, in large part, for the apparent discrepancy.

First, more than 9 percent of the Lake Crook watershed consists of practically flat alluvial flood plains, the largest of which extend along the lower 3 or 4 miles of the north and south branches of Pine Creek, and range from one-quarter to one-half mile in width in their lower part but narrow gradually upstream. The periodic overflow and deposition which occurs on portions of these areas undoubtedly accounts for some of the missing topsoil of the eroding fields. An additional 1.6 percent of the watershed, or 543 acres, consists of colluvial deposits at the foot of slopes, which are composed of soil washed from the fields immediately above. If the average thickness of colluvial deposits is only 2 feet, the accumulation in these areas would be 1½ times the amount deposited in Lake Crook during the 13-year period of record. If, in addition, an average of 6 inches of sediment has been laid down on the alluvial flats, the total accumulation above the reservoir would be 3 times that in the reservoir. More than 10 percent of the area is thus receiving a part of the wasting soil from the eroding areas. In the Lake Gibbons watershed, on the other hand, only 0.4 percent of the area (3 acres) has alluvial soils and 3 percent, or 24 acres, has colluvial soils. It therefore appears that a much smaller proportion of the erosional debris coming from the smaller watershed is subject to deposition above the reservoir than in the case of Lake Crook.

Secondly, table 2 shows that Lake Gibbons has approximately 5 times as much storage capacity per unit of drainage area as Lake Crook, which, assuming uniform rainfall and run-off over the combined area, means that Lake Gibbons has a correspondingly greater capacity-inflow ratio. Any reservoir which is subject to continuous or periodic overflow bypasses a certain proportion of the incoming silt load, but it is evident that of two reservoirs having other factors equal, the one with the largest capacity-inflow ratio will have the slowest passage of water through it and will therefore offer the greatest opportunity for permanent settling of sediment. Correspondingly, Lake Gibbons should be bypassing a much smaller proportion of the incoming sediment than Lake Crook.

To summarize, it is suggested that a greater opportunity for upstream deposition and a smaller capacity-inflow ratio account for the lower rate of silt accumulation per unit of drainage area from the more severely eroding Lake Crook watershed.

It is believed, furthermore, that these data emphasize very strongly the need for careful consideration in adjusting the location and capacity of prospective reservoirs to the size and characteristics of the watershed, with particular reference to soil erosion and facilities for its control.

SUMMARY

The data collected during this survey reveal the following significant points:

1. The chief characteristic of the reservoir sediment is uniformity, in distribution, in texture, and in composition.

2. A considerable but unknown fraction of the incoming silt load is carried in suspension through the reservoirs and over the spillways.

3. Inasmuch as practically all the lake sediment is derived from sheet erosion and minor gully erosion on 75 percent of the watershed, conservation of the remaining storage capacity will depend on widespread application of erosion control practices.

The results of the two surveys are summarized in table 3.

Table 3.--Statistical summary of data relative to Lakes Crook and Gibbons, Paris, Texas

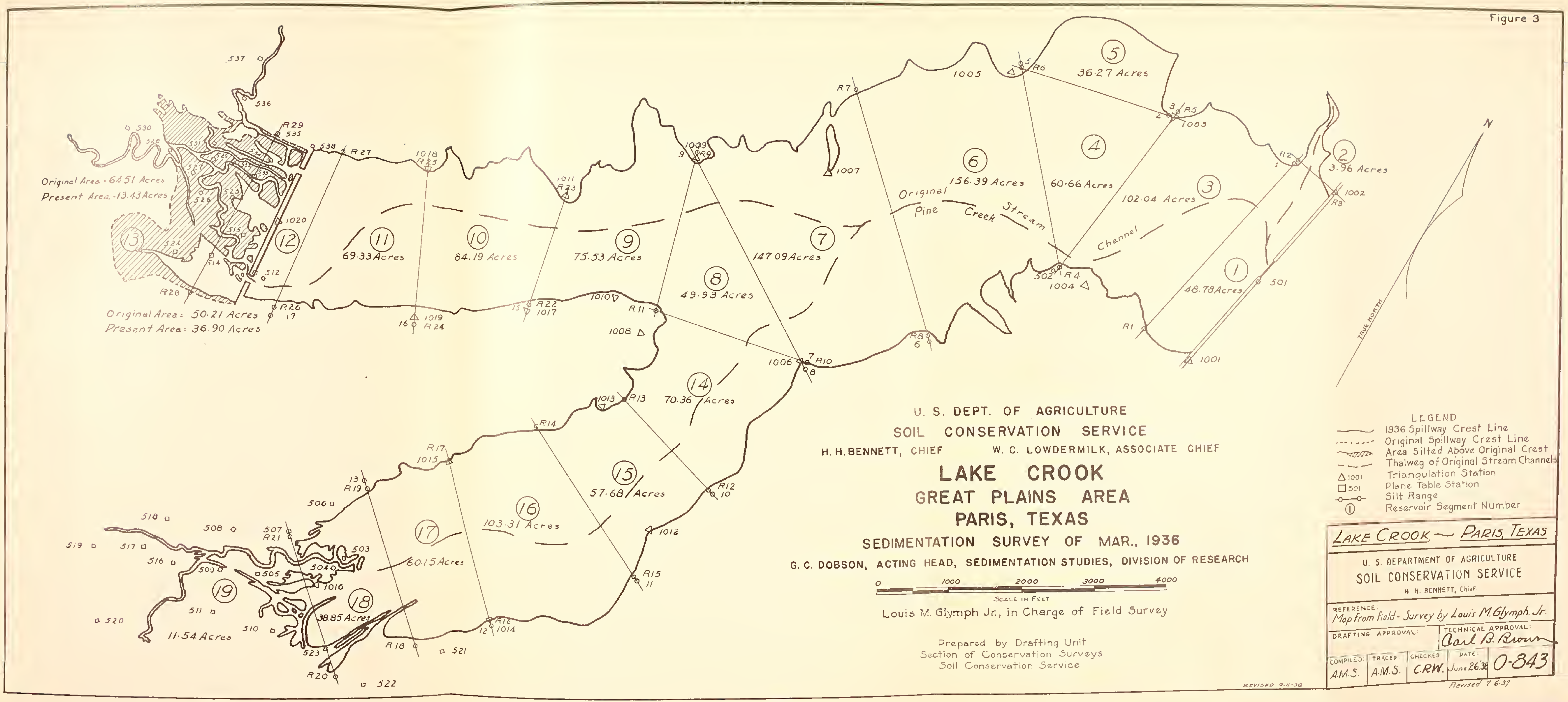
Item	Quantity: Lake Crook	Quantity: Lake Gibbons	Unit
Age	1/ 13.1	2/ 36	Years
Watershed:			
Total area	3/ 51.6	1.26	Square Miles
Reservoir:			
Original area at crest stage.	1,291	131.3	Acres
Present area at crest stage..	1,227	130.5	Acres
Original storage capacity....	11,487	1,414	Acre-feet
Present storage capacity.....	10,755	1,336	Acre-feet
Original storage per square mile of drainage area.......	222.62	1,122.22	Acre-feet
Present storage per square mile of drainage area.......	208.43	1,060.32	Acre-feet
Sedimentation:			
Delta deposits...............	) Not measured separately		
Bottom-set beds..............	)		
Total sediment	732	78	Acre-feet
Average accumulation per year	55.9	2.17	Acre-feet
Accumulation per year per 100 square miles of drainage area	108	172	Acre-feet
Accumulation per year per acre of drainage area.......	73.73	117.22	Cubic-feet
Or, assuming average weight of 1 cubic foot of silt is 100 pounds............	3.69	5.86	Tons
Depletion of storage:			
Loss of original capacity per year	0.49	0.15	Percent
Loss of original capacity to date of survey	6.37	5.52	Percent

1 Date storage began: February 1923. Date of this survey: March 1936.

2 Date storage began: 1900 (month undetermined). Date of this survey: March 1936.

3 Exclusive of Lake Gibbons drainage area.

Figure 3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LAKE CROOK
GREAT PLAINS AREA
PARIS, TEXAS
SEDIMENTATION SURVEY OF MAR., 1936
G. C. DOBSON, ACTING HEAD, SEDIMENTATION STUDIES, DIVISION OF RESEARCH
0 1000 2000 3000 4000
SCALE IN FEET
Louis M. Glymph Jr., in Charge of Field Survey
Prepared by Drafting Unit
Section of Conservation Surveys
Soil Conservation Service
LEGEND
1936 Spillway Crest Line
Original Spillway Crest Line
Area Silted Above Original Crest
Thalweg of Original Stream Channels
1001 Triangulation Station
501 Plane Table Station
Silt Range
Reservoir Segment Number
LAKE CROOK ~ PARIS, TEXAS
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. BENNETT, Chief
REFERENCE:
Map from Field-Survey by Louis M. Glymph, Jr.
DRAFTING APPROVAL:
TECHNICAL APPROVAL:
Carl B. Brown
COMPILED: A.M.S.
TRACED: A.M.S.
CHECKED: C.R.W.
DATE: June 26 '36
0-843
Revised 7-6-37
REVISED 9-11-36
TRUE NORTH
N
Original Pine Creek Stream Channel
Original Area: 64.51 Acres
Present Area: 13.43 Acres
Original Area: 50.21 Acres
Present Area: 36.90 Acres
1 48.78 Acres
2 3.96 Acres
3 102.04 Acres
4 60.66 Acres
5 36.27 Acres
6 156.39 Acres
7 147.09 Acres
8 49.93 Acres
9 75.53 Acres
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11 69.33 Acres
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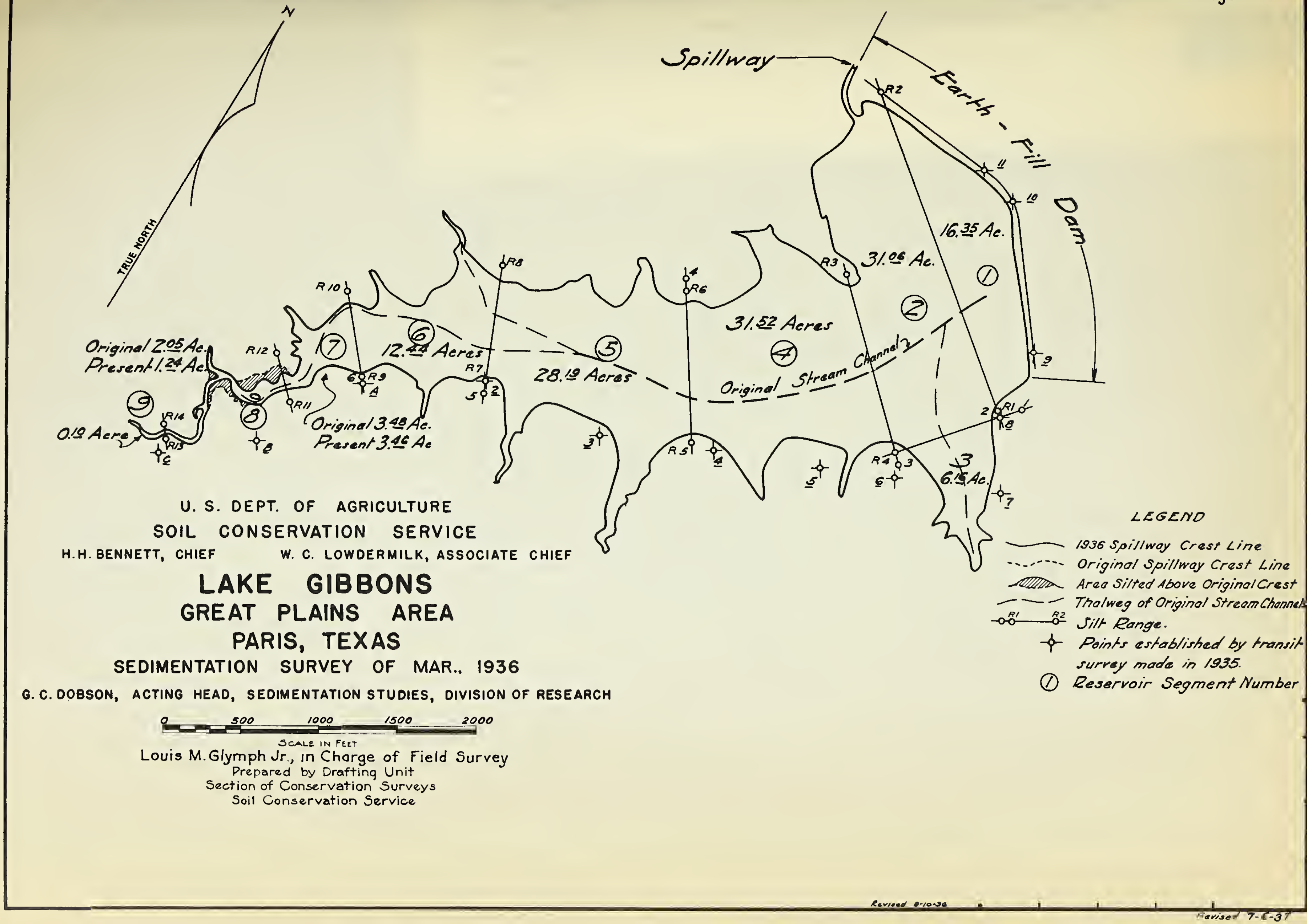
16 103.31 Acres
17 60.15 Acres
18 38.85 Acres
19 11.54 Acres

Figure 4


Spillway
Earth - Fill Dam
TRUE NORTH
N
16.35 Ac.
31.06 Ac.
31.52 Acres
28.19 Acres
12.44 Acres
6.15 Ac.
Original Stream Channel
Original 2.05 Ac.
Present 1.24 Ac.
Original 3.48 Ac.
Present 3.46 Ac
0.19 Acre
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Revised 8-10-36
Revised 7-6-37